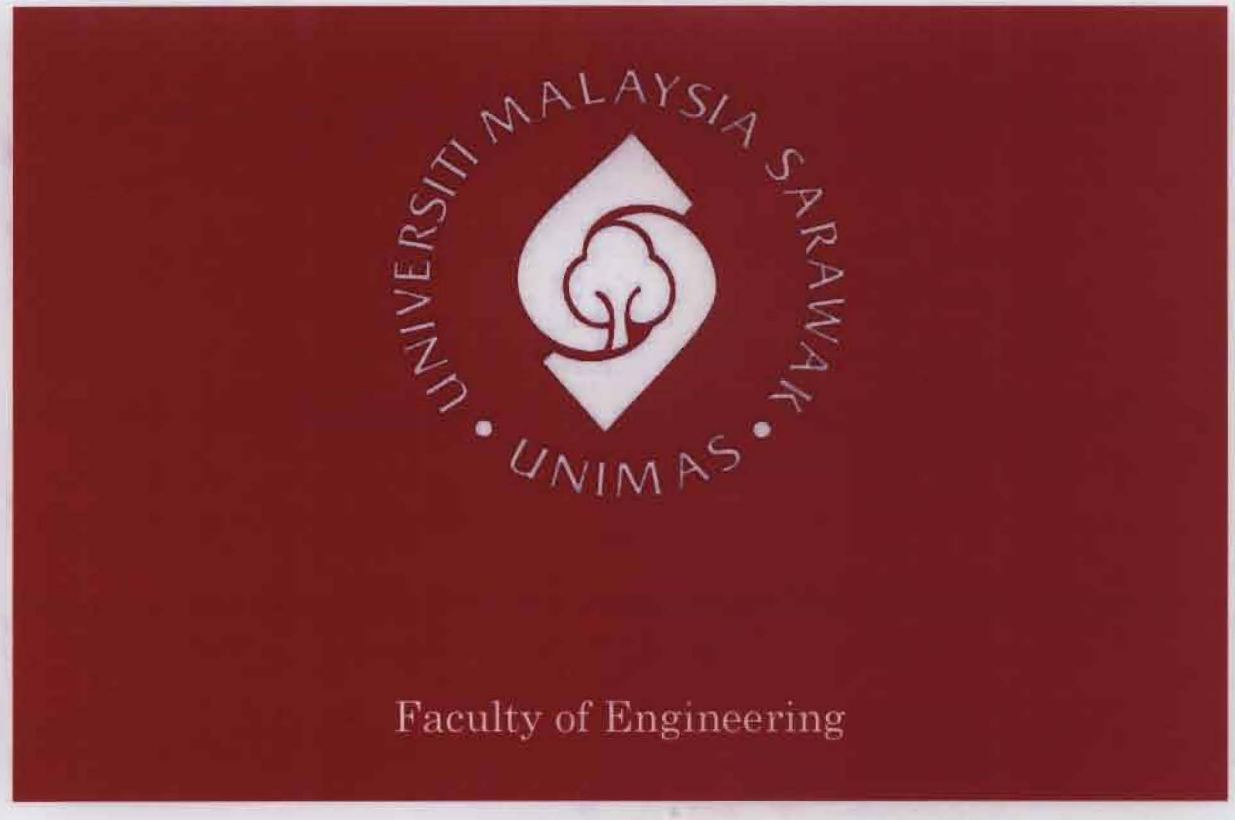

DESIGN SETUP FOR THE STUDY OF REDUCTION IN VISCOSITY OF SUBSEA CRUDE OIL USING HYDRODYNAMIC, ELECTROSTATIC AND MAGNETIC FORCES COUPLED WITH NON-THERMAL PLASMA (NTP) INJECTION IN THE CRUDE OIL

Nur Sharzaina Hanum Binti Sekiun

Bachelor of Engineering with Honours

(Mechanical and Manufacturing Engineering)

2017

UNIVERSITI MALAYSIA SARAWAK

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I Nur Sharzaina Hanum Binti Sekiun, 43279, WK18 Faculty of Mechanical and Manufacturing Engineering hereby declare that the work entitled Design Setup for the Study of Reduction in Viscosity of Subsea Crude Oil Using Hydrodynamic, Electrostatic and Magnetic Forces Coupled with Non-Thermal Plasma (NTP) Injection In The Crude Oil is my original work. I have not copied from any other students' work or from any other sources except where due reference or acknowledgement is made explicitly in the text, nor has any part been written for me by another person.

29th July 2017
Date submitted

NUR SHARZAINA HANUM
43279
Name of the student (Matric No.)

Supervisor's Declaration:

I Prof Ir Dr Andrew Ragai Henry Rigit hereby certifies that the work entitled Design Setup for the Study of Reduction in Viscosity of Subsea Crude Oil Using Hydrodynamic, Electrostatic and Magnetic Forces Coupled with Non-Thermal Plasma (NTP) Injection In The Crude Oil was prepared by the above named student, and was submitted to the "FACULTY" as a * partial/full fulfillment for the conferment of Bachelor of Engineering with Honours in Mechanical and Manufacturing Engineering, and the aforementioned work, to the best of my knowledge, is said the student's work.

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This project report which entitled "**DESIGN SETUP FOR THE STUDY OF REDUCTION IN VISCOSITY OF SUBSEA CRUDE OIL USING HYDRODYNAMIC, ELECTROSTATIC AND MAGNETIC FORCES COUPLED WITH NON-THERMAL PLASMA (NTP) INJECTION IN THE CRUDE OIL**," was prepared and submitted by Nur Sharzaina Hanum Binti Sekiun (43279) as a partial fulfilment of the requirement for degree of Bachelor of Engineering with Honour (Mechanical and Manufacturing Engineering) is hereby read and approved by:

Date:..... 24/7/2017

Prof Ir Dr Andrew Ragai Henry Rigit

Project Supervisor

Faculty of Engineering

Universiti Malaysia Sarawak

DESIGN SETUP FOR THE STUDY OF REDUCTION IN VISCOSITY OF SUBSEA CRUDE OIL USING HYDRODYNAMIC, ELECTROSTATIC AND MAGNETIC FORCES COUPLED WITH NON-THERMAL PLASMA (NTP) INJECTION IN THE CRUDE OIL

NUR SHARZAINA HANUM BINTI SEKIUN

Thesis is submitted to

Faculty of Engineering Universiti Malaysia Sarawak

In Partial Fulfilments of the Requirements

For the Degree of Bachelor of Engineering

With Honour (Mechanical and Manufacturing Engineering)

2017

To my beloved family

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LIST OF ABBREVIATIONS

EOR	-	Enhanced Oil Recovery
DBD	-	Dielectric Barrier Discharge
NTP	-	Non-Thermal Plasma
PPT	-	Plasma Pulse Technology
API	-	American Petroleum Institute
AC	-	Alternating Current
DC	-	Direct Current
DOE	-	Design of Experiment
OES	-	Optic Emission Spectroscopy

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ABSTRACT

The use of the non-thermal plasma for the purpose of the enhanced oil recovery has been limited due to the dimensions of the area under effect. Yet the research based on using non-thermal plasma stretches from surface treatment of polymers till medical treatment of wounds but still its use in Enhanced Oil Recovery (EOR) needs more attention from scientific community.

In the current manuscript a concept has been presented in which the application of the high potential using Di-Electric Barrier Discharge (DBD) on the crude oil along with the application of separate electrical and magnetic fields will be persuaded. The effect of these methods will be judged by the Kerr and Pockel's effects whereas the separation of the desired species will be attained using separate electrical and magnetic filters.

With the help of this setup it could be hoped that Hydrodynamic, Electrical and Magnetic force's effect will be studied. Along with it the effect of injection of a specific type of species on the effectiveness of plasma will be studied as well. The crude oil impinged with non-thermal plasma rich with a specific type of species imparted by the direct injection of the non-thermal plasma into the crude oil in a coupling flow loop mechanism will be investigated.

The proposed methodology is in refining and designing stage and will be experimented after wards. Here the research idea has been shared and the results will be published after when the experiments have been conducted.

ABSTRAK

Penggunaan plasma bukan haba untuk tujuan pemulihan minyak dipertingkatkan telah terhad kerana dimensi kawasan di bawah kuasa. Namun penyelidikan berdasarkan menggunakan plasma bukan haba bermula dari rawatan permukaan polimer sehingga rawatan perubatan luka tetapi masih penggunaannya dalam Peningkatan Pemuliharaan Minyak (PPM) memerlukan perhatian yang lebih daripada komuniti saintifik.

Dalam manuskrip semasa konsep yang telah dibentangkan di mana permohonan yang berpotensi tinggi menggunakan Pelepasan Di-Electric Barrier (DBD) di minyak mentah bersama-sama dengan penggunaan medan elektrik dan magnet berasingan akan dipujuk. Kesan kaedah ini akan diadili oleh kesan Kerr dan Pockel ini manakala pemisahan spesies yang dikehendaki akan tercapai menggunakan penapis berasingan elektrik dan magnet.

Dengan bantuan persediaan ini ia boleh berharap hidrodinamik, elektrik dan kesan daya magnet yang akan dikaji. Bersama-sama dengan kesan suntikan sesuatu jenis spesies mengenai keberkesanan plasma akan turut dikaji. Pergandingan minyak mentah dengan plasma bukan haba kaya dengan sesuatu jenis spesies disampaikan melalui suntikan langsung plasma bukan haba ke dalam minyak mentah dalam mekanisme gelung aliran gandingan akan disiasat.

Kaedah yang dicadangkan adalah dalam penapisan dan mereka bentuk peringkat dan akan diujkaji pada masa akan datang. Di sini idea penyelidikan yang telah dikongsi dan keputusan akan diumumkan selepas apabila eksperimen telah dijalankan.

CHAPTER 1

INTRODUCTION

1.1 Project Background

Waste product as crude oil now can be very useful. As it can be convert to better products for our daily life. Nowadays oil considered as our major needs for daily life, life is very impacted to oil (Refining Crude Oil, n.d.). This is because we need oil in most of our transportation vehicle, health machine, plastic we used, cosmetics and even our personal daily product wet oil (Refining Crude Oil, n.d.). If we depend on our natural source until the end, it will not be sufficient to give us supply (Refining Crude Oil, n.d.). Hence, another alternative that is refining process of crude oil molecule is needed before this can be converting to out desired product (Refining Crude Oil, n.d.).

This large crude oil molecule will be broken down to smaller molecule that is called as fractions and can be used on many different purpose depend on the molecule its break down into. This process of breaking down of large crude oil molecule to smaller size fractions is called a cracking process. This chemical reaction will produce shorter hydrocarbon chain including alkanes and alkenes. From the alkanes we can produce polymer as it's an unsaturated hydrocarbons and as well ethane can be used to make ethanol for various purpose. These days most type of crude oil is tried to be refine to prevent the waste of the crude oil all over the world (Refining Crude Oil, n.d.).

In Paraguana, 940,000 barrels of crude oil being process daily which make it as the largest oil refinery in Venezuela. In fact Asia and South America are defined as the largest refinery oil industry (Refining Crude Oil, n.d.). Some country like United State also practicing this oil refining process to boost the nation's economy (Refining Crude Oil, n.d.).

Cracking is done because the crude oil molecule is made up of a large and long hydrocarbon that is not efficient. Thus this type of oil is difficult to ignite because it cannot react with oxygen in the air and cannot flow easily. This crude oil often to contain large hydrocarbon and it cannot meet demands. This is why the cracking process is subjected to it.

The first people that introduce this refining process of oil are Samuel M. Kier that is a native of southwestern Pennsylvania (Refining Crude Oil, n.d.). While running his salt business in the mis-1840s he notices of this crude oil (Refining Crude Oil, n.d.). The finding of the oily product while drilling for salt water make him thinks if he can turn the oily by product into something that is more valuable (Refining Crude Oil, n.d.). But the oil he obtain produce smell and make him too the sample to be refine by some chemist (Refining Crude Oil, n.d.).

As time goes by many modification of process of refining the crude oil molecule had been done to increase the production efficiency, hence a major difference from the old method can be seen in term of technology and also the result of the process (Refining Crude Oil, n.d.). Back then Kier use method that rise the temperature of the crude oil very slowly (Refining Crude Oil, n.d.).

As for today many modification including manufacturing, transporting and handling this reefing process has been made to make sure continuous supply for daily use (Refining Crude Oil, n.d.). This refining process is a mess process and some restriction has been made to minimize the drawback of this process and of increasing effort to make this process as the cleaner industry as time goes by (Refining Crude Oil, n.d.).

Cracking process not only able the crude oil to ignite and produce gasoline but also the different reaction structure leads to more useful hydrocarbon molecules. The cracking

process not only limited to one type of operation. This cracking process can be done through a few methods that give out different type of product depends on its operation.

Some force need to be exert on the large and long hydrocarbon molecule so that the molecule receive enough energy for it to reach its excited state where in this state the bond between molecule will be broken and the molecule move vigorously and combine to other free atom to complete it bond in form of smaller and shorter hydrocarbon chain.

Cracking can be done by various type of procedure. For example by applying an high voltage, thermal cracking by applying high temperature, catalytic cracking by addition of catalyst in reaction, hydrocracking by adding hydrogen in reaction and last but not least steam cracking by adding hot steam during reaction.

Nowadays plasma technology are widely used as now people how much advantage this refining or cracking technology can give to various sector (Staack, n.d.). This process usually take place at high temperature or/and high pressure (Staack, n.d.).

Non-thermal plasma injection into liquids for the purpose of reduction in viscosity as well as to generate high energy electrons and low energy charged radicals or ions or species can be used for crude oil treatment as well as for food processing and in medical for healing of chronicle wounds is a topic worthy to draw attention of the present day pool of intellectuals. The main theory on coarse level emphasis on the injection of the high energy/voltage electric pulse into the fluid (Crude oil) by using two electrodes which could have any configuration e.g. point to plane and plane to plane.

As a result of this injection electrical breakdown takes place. Our understanding regarding this breakdown phenomenon is limited especially when the plasma is injected inside the crude oil or other hydrocarbons having viscosity of considerable range. Yet in the case of the plasma injection in the gases we are much understood about the plight of the domain for more than several decades ago, but for the case of liquids we are still wandering in black. So a deep understanding of the effect of the plasma injection in the Crude oils like paraffin based or asphalt based is vital to know.

The understanding will be broadened more by observing the scenario after injection of high voltage across two electrodes inside the crude oil as well as by investigating the effect of the three types of forces i.e. hydrodynamic, electrostatic as well as magnetic on the crude

oil. As a possible outcome not only we will get much assured about the onsite phenomenon but also the ways and methods will be sought and conditions will be optimized for increasing the affectivity of the high voltage application as well as plasma injection in the area under operation (i.e. the crude oil samples in between the two electrodes).

From affectivity we here desire to make the crude oil samples rich with charged species and high temperature electrons. It can be proposed that an increase in the affectivity of the non-thermal plasma at the same cost as invested in the methods applied in the present days will straight forward affect the monetary incentives in terms of reduced amount of power or resources which are required for reducing the viscosity of crude oil using EOR methods. It should also be emphasized that the proposed method should be clean from any environmental hazardous compounds, but before coming to the topic, proposed methodology and references where same methods have proved their vitality, first the reader should be acquainted with the present scenario in the Enhanced Oil Recovery market.

In the Enhanced Oil Recovery (EOR) methods the explorations based on the fracking now are facing with slight cuts due to a number of reasons. The Fracking technology uses huge amount of water that needed to be transported to the fracking site, at significant cost. Further, several chemicals are used in fracking which are supposed to be carcinogenic. Contamination of the ground water is also significant to mention. The key problems of extracting shale gas are enumerated below:

- Expensive technique of fracturing and horizontal drilling technology
- Large scale use of water and chemicals
- Contamination of ground water aquifers
- Risk of earthquakes
- Coincide of many common areas under shale gas and natural gas reserves producing problems in contemporary extraction of shale gas and natural gas.
- Under mismanagement, the hydraulic fracturing fluids can be released by spills, leaks or various other exposure pathways polluting the surroundings.
- Shale gas transportation and storage is a difficult process.

With the stated reasons, the low oil prices condition forced the fracking industry to the edge because high expenditure on drilling having sidelined rigs and result in decreasing oil production time-by-time in second half of 2015. Supplement to this drawbacks, life of any operating in this industry will be well limited, this frustration targeted only to give out about 10 to 40 percent of whole oil reservoir although using both primary and secondary recovery attempt, based on U.S Department of Energy. Thus, the demand for oil recovery is very high (Kress, 2014)

As with anti-fracking new regulations in California cause negative result in July 2014 and a victorious anti-fracking agreement in early December 2014 take place in Denton, Texas giving positive impact to this situation. Anti-drilling new California's bill that is SB4 now focusing more to hydraulic fracturing and the effect cause so much restriction on acid washing on related place that is 42,000 injector wells that capable of producing 200,000 and more barrels of oil in one day.

These regulations will have a profound effect on key producers in the area, such as Chevron Corp, Exxon Mobil and Occidental Petroleum. So the industry now is focusing on new methods that reduce unwanted product waste (Burgess, 2014). To point related issue a new method or alternative that is also known as Plasma Pulse Technology (PPT). Plasma Pulse is basically a new and approachable alternative that have been introduced in purpose of enhanced oil recovery (EOR) industry in the United States.

The PPT was invented at St. Petersburg State Mining University in Russia. Other than injecting the well with high pressure fluid to produce fracture to help in oil recovery process, this Plasma Pulse Technology PPT also known as easy in develop technology. This technology also includes the use of, vibrations or plasma impulses in order to help to reduce the oil viscosity at the same time improve oil permeability and enhance gas and oil flow to the surface where extraction take place.

Thus it can be hoped that this could help in the separation between oil and gas producers. And at the same time help environmentalist and regular citizen to ease their worry of the effect of toxic chemical waste will pollute their groundwater in the process. Our investigations will fully alter these ideas and designed experiments to some extent small or large, more broad based effects would tried to be produced on the basis of

implementing the Non-thermal Plasma (NTP) as compare to those based on the present day practiced methodologies.

The affectivity of NTP injection into both types of crude oils i.e. paraffin as well as asphalt based crude oils in presence of the mentioned forces e.g. hydrodynamic, electrostatic and magnetic would be increased to reduce the viscosity of both types of crude oils. The main investigations will include the observation of the pre-breakdown expansion and the formation of instability plus the effect of the charged species density inside the crude oil as well as the observation of the generation of nonlinear, wide band, periodic and directed elastic oscillations produced by the treated crude oil when injected inside the untreated crude oil.

1.2 Existing market size

Till the date the major part player in the market is PROPELL TECHNOLOGY GROUP INC [REF] which is using the Plasma Pluse Technology (PPT) in the EOR for oil production.

Figure 1.2.1: Potential Acquisition Area Basins

Whereas the potential areas basins under its operations in USA are shown in Figure 1.2.1. Whereas it is the exclusive license holder of the proprietary EOR technology using plasma. The main system composed of a moveable locomotive based station about which the details are as under Figure 1.2.2-1.2.4;

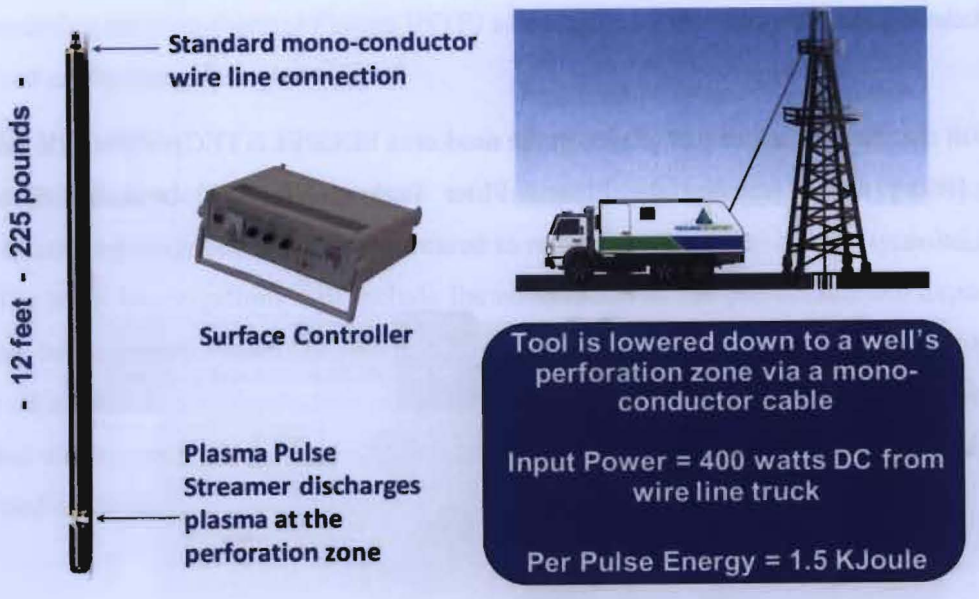

Figure 1.2.2: Apparatus for ground based EOR operations

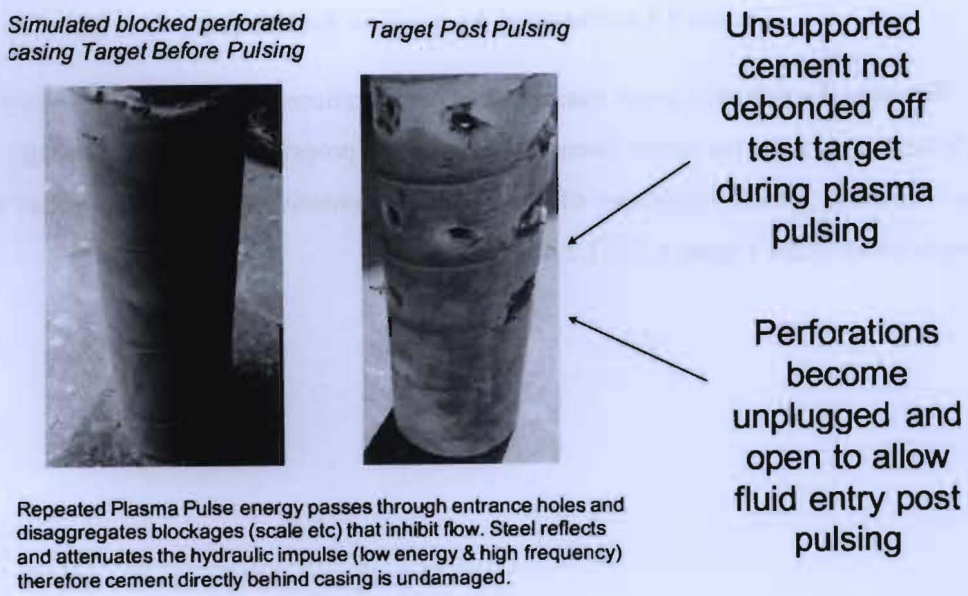

Figure 1.2.3: Details of plasma pulse streamer discharge for ground based EOR operations

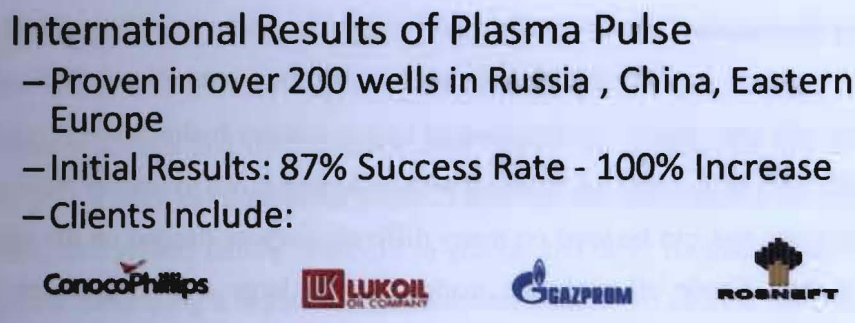

Figure 1.2.4: Effectiveness of Plasma Pulse Technology: A fact sheet based on past experiences

1.3 Problem Statement

Crude oils are complex combination of long and heavy hydrocarbon (Cold Cracking Report, 2006).This large crude oil molecule will be broken down to smaller molecule that is called as fractions and can be used on many different purpose depend on the molecule its break down into. Crude oil molecule made up of a large and long alkane molecule (Cracking Hydrocarbons - useful products, n.d.). Heavy crude made up of a large and long hydrocarbon that is not efficient. Crude oil is not easy to flow under normal production and it is considered as highly viscous oil (Heavy Crude Oil, 2014).

With it heavy molecular composition this oil defined as heavy for oil group (Heavy Crude Oil, 2014). This characteristic makes it likely to accumulate at the bottom (Heavy Crude Oil, 2014). Crude oil is place in dense non-aqueous phase liquid and heavy low solubility (Heavy Crude Oil, 2014). Crude oil is a mixture of substance that is hydrogen and carbon (Chemistry, 2014). The higher value of carbon atom in a single hydrocarbon chain, the higher boiling point of the molecule (Chemistry, 2014). Heavy hydrocarbon usually contains more than one unit of sulphur, nitrogen and also metals (Cold Cracking Report, 2006).

Heavy crude thicker compared to other type of oil and have API gravity less than 20 (Petroleun.co.uk, 2015). Heavy types of crude oil have more resistant to flow (Petroleun.co.uk, 2015). These characteristic make the heavy crude difficult to extract, transport and refine (Discharge in Liquids for lightning of heavy oil, n.d.).Thus, this type of oil is difficult to ignite because it cannot react with oxygen in the air and cannot flow easily. Hence, cracking or refining process is needed to make the crude oil as a useful product. Refining process of this crude hydrocarbon will include the braking of some bonds and also producing mew bond that is theoretically consist of shorter and lighter hydrocarbon (Cold Cracking Report, 2006).

Subsea oil explorations produce crude oil which is very viscous. In addition to it it's transportation from the subsea oil well to the onshore process facilities make it flow through high temperature variant waters below sea level. Because of this, their need require more efforts to assure the confirmation and production of oil recovery from well and its